THE NAUTILUS

Vol. 55 April, 1942 No. 4

THE HABITS OF LIFE OF SOME WEST COAST BIVALVES

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The observations upon which I am to report were made during my visit to California in the months of April and May of last year. Their accomplishment in such a short time would have been impossible without the accommodations for collecting and study which the Scripps Institution of Oceanography at La Jolla and the Hopkins Marine Station at Pacific Grove kindly put at my disposition; I was furthermore much helped by the active aid of West Coast malacologists and especially by Dr. Joshua Baily of San Diego and Dr. Myra Keen of Stanford University.

1. *The Boring of Lithophaga.* At the 1940 meeting of our society at Philadelphia, Dr. Bales reported on his observations on Floridan boring mussels and he touched on the problem as to how a bivalve with as soft and as smooth a shell as *Lithophaga* could successfully attack hard rock. In this connection, I then could refer to Kühnelt's experimental work with Mediterranean lithophagas, in which he proved that the carbonic acid produced by the animal's mantle edges is the solvent agent; this shows that *Lithophaga* is not a mechanical borer, as are the teredinids and pholadids, but a chemical one. This explanation of its boring powers is, of course, only true in the case of limestone rocks, and all the *Lithophaga* holes in the Mediterranean and the Floridan regions were indeed bored into calcareous rocks.

On the California coast, I collected *Lithophaga plumula* Hanley at La Jolla. To my great astonishment, this species had perforated what seemed to be a coarse sandstone, but how could a a siliceous rock be attacked by a chemical borer, with an acid no stronger than carbonic acid? A chemical and petrographical

analysis made it clear later, that while the rock in question is composed of medium to coarse grains of quartz and feldspar, these components are cemented together by calcium carbonate. This accounts for the possibility of its being drilled by *Lithophaga*. The cementing lime is first dissolved by the action of the carbonic acid, and the loosened grains of quartz and feldspar are then washed out by the water currents produced by the bivalve. The bore-hole is constantly lined with a thin layer of amorphous calcium carbonate.

The assumption that chemical boring is the only means of attacking a rock, even a sandstone like that described, is thus not contradicted, and is further supported. But it utterly fails to explain how *Lithophaga* can drill holes in the argillaceous shale. I found this kind of rock, which does not contain a trace of soluble lime, settled upon and perforated by *Lithophaga plumula*, both at La Jolla and at Pacific Grove. Chemical boring is completely out of the question in this case; mechanical drilling, by rotation of the shell, cannot be proven and is improbable, since the exterior surface of the *Lithophaga* shell does not exhibit any vestige of being worn or ground. As in bore-holes drilled in other kinds of rock, those in the shale are lined out with amorphous calcium carbonate. The fact that *Lithophaga* can drill holes in non-calcareous argillaceous rocks is thus established, but it cannot yet be explained in any way.

Lithophaga plumula is accompanied, in this shale, both by mechanical borers, such as *Venerupis lamellifera*, some pholadids and *Petricola carditoides*, and by a bivalve apparently unfit for boring, *Botula californiensis*, which probably bores by the same unknown means as *Lithophaga plumula*.

2. *Protective Coverings Built by Two West Coast Bivalves.* Very little is known about nest building habits of bivalves. Text-books, even the most recent ones, mention only the case of limids, which construct a kind of camouflaged nest from byssus-threads and shell fragments or stones, and that of juvenile mytilids, which occasionally have a similar habit. There are, however, other examples of this habit, as I had opportunity of learning on the Californian coast, where nest cases built by *Diplodonta orbella* Gould and by the myid *Cooperella subdiaphana* Carpenter are known.

Let us speak first of *Diplodonta orbella*. This species is rather common, and almost every shell collector on the West Coast knows that it has the habit of building a "nest," as the protective covering is called. Notwithstanding this knowledge, there are scarcely any hints in the literature referring to this nest-building habit. None of the textbooks mentions it, and only scanty, insufficient remarks in rather obscure places give evidence that the fact has been observed. I tried to trace back the literature on this subject and found, as the oldest quotation, a collecting notice in NAUTILUS, 9, 1895, p. 72, in which *Diplodonta orbella* is reported to have been collected "with nests"; the way these "nests" are mentioned, seems to allude to a matter of common knowledge. Josiah Keep, in the first edition of "West Coast Shells," (1893) does not say a word about the nest of our bivalve; so the first source of concise information about our subject is Dall's "Synopsis of the Lucinacea and of the American Species," 1901, where, on page 795, it is stated of *Diplodonta orbella* that "It is the habit of the animal to form a sort of nest of sand and adventitious matter, cemented by mucus, with long tubular openings, the whole of irregular form, but completely concealing the inmate." No picture is given. Josiah Keep, in the latter editions of the "West Coast Shells" (1904, 1911 and the 1935 edition revised by Dr. Joshua Baily), repeats this statement in almost identical words, adding the words "for the siphons," so that Dall's original description now runs "with long tubular openings for the siphons." Charles R. Orcutt's "Molluscan World" of 1915, which contains so many valuable observations on molluscan life, did not mention the *Diplodonta*-nest.

The first picture of such a *Diplodonta*-covering appeared in Johnson and Snook's "Seashore Animals of the Pacific Coast" in 1927; the text accompanying figure 416, on page 438, states "This species forms a protecting covering of sand cemented by mucus. The covering has long tube-like extensions in which the siphons lie, so that the mollusk is quite hidden." The 2nd edition of the "Seashore Animals of the Pacific Coast, from 1935," literally repeats this statement. Keen and Frizzell, 1935, mention only "nests" in connection with *Diplodonta orbella*. No further literature on this subject has come to my knowledge.

Thus by way of a résumé, our knowledge of the *Diplodonta*-nest consists of a rather vague description and of a single picture. This picture shows the partly broken covering exhibiting two long posterior extensions in which, according to the descriptions given by Keep and by Johnson and Snook, the siphons lie. But this explanation cannot be correct, at least concerning the specimen shown in my photograph, in which there is a third though shorter posterior extension, and no bivalve with three siphons is known! A still closer inspection of the specimen reveals the fact that the three extensions are not hollow tubes at all, but incrusted stalks of seaweeds; they cannot be, therefore, protective coverings of the siphon. They may be regarded as mooring ropes of the shell-covering, as a kind of protection against the shifting action of the waves. Nests with this structure constitute the most abundant type; they all exhibit extensions, variable in number and of variable length, which either still contain the stalks of seaweed or are hollow when their original axis of vegetable matter has become disintegrated. This type of nest is built from a felt-like material containing practically no mineral particles and consisting probably of disintegrated plant fibers, kept together by a cementing secretion of the animal. This type of nest may be found loose in holes and crevices of rocks or in empty bivalve shells in which they practically fill out the shole space between the living *Diplodonta* and the dead shell used as a shelter.

Besides the type of *Diplodonta*-nest just described, a rarer one may be found which corresponds much more closely to the descriptions cited above. Two specimens of *Diplodonta orbella* in coverings of cemented sand exhibit two long posterior extensions which correspond in position with the siphons of the enclosed animal. These extensions, however, are not hollow either, or at least are not originally hollow but certainly are incrustations of stalks of plant material also! Thus the explanation of these extensions of siphon-coverings, originated by Keep and carried along by Johnson and Snook, cannot be maintained and has to be given up in favor of their tentative explanation, as anchoring ropes, as a protection against the action of the waves.

My conclusions had come thus far, when it occurred to me that some information about the length and the general structure

of the *Diplodonta*-siphon might be important. It certainly *was* important, for the information I found in Dall's words (1901, p. 795) is as follows: "There are two entire siphonal orifices, without siphons." Where there are no siphons, no siphonal coverings are needed; thus the explanation of the nest extensions as siphonal tubes is entirely baseless.

In all the cases which came to my observation, the *Diplodonta*-covering seems to consist of two halves corresponding to the two valves of the shell, opening at the ventral side and united at the dorsal side of the animal. Nothing is known as yet of the way in which *Diplodonta orbella* constructs its two kinds of coverings, though it ought not be too difficult to watch its construction in an aquarium. It is hoped that my paper may stimulate some West Coast malacologist to study this interesting problem.

I mentioned above that the myid bivalve *Cooperella subdiaphana* Carpenter also has the habit of constructing a protective covering. I have not found one myself, but I saw specimens both in the Los Angeles Museum and in the Stanford University Collection. To the best of my knowledge, Keen and Frizzell (1935, p. 23) are the first to mention the *Cooperella*-covering, describing it as a "nest of agglutinated sand"; but no picture of the object has ever been published. The dried covering is rather solid; it is closed all around, leaving only a slit on the posterior extremity open for the communication of the inmate with the outer world.

COLLECTING IN MEXICO

By A. SORENSEN

On my three trips to Guaymas, Mexico, for the purpose of studying and collecting specimens of the wonderfully ample marine life there I made a number of observations, which may be worth recording. As a collecting place of marine life Guaymas can hardly be excelled for it has all the different kinds of shore fronts from sandy beaches to rocky stretches and offshore islands. Besides these the Miramar Lagoon, San Carlos Bay, Esterro Soldado and San Ramon Bay furnish, at low tides, sand spits, mud flats and large sand bars, all easily accessible by auto.